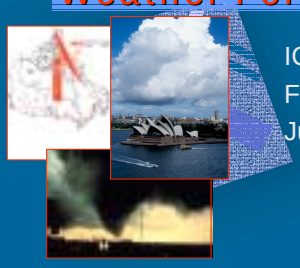
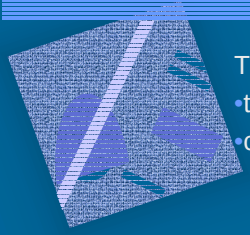
Tornadoes and Severe Weather Forecasting



ICLR
Friday Forum
June 8 2001

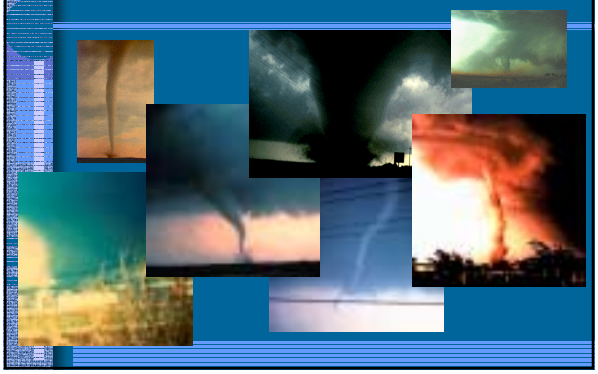
Outline

- Tornadoes
- Tornadoes formation
- Current Severe Weather Forecast Practices
- Future Forecasting/Nowcasting
  - Sydney 2000 Project



Tornadoes
- types
- classification

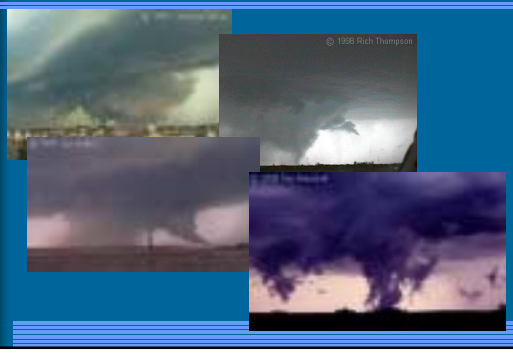
Tornadoes



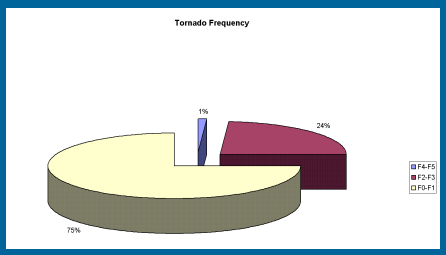
Tornado Classification

Scale	MPH	Expected Damage
F-1	73-112	Moderate Damage
F-2	113-157	Considerable Damage
F-3	158-206	Severe Damage
F-4	207-260	Devastating Damage
F-5	261-318	Incredible Damage

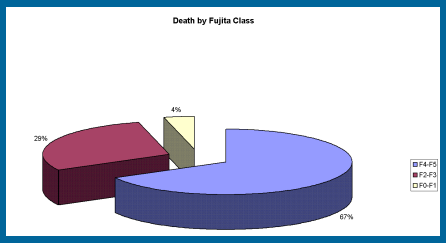
to be or not to be



Frequency by Class



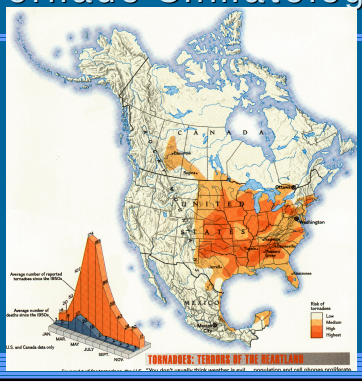
Deaths by Class



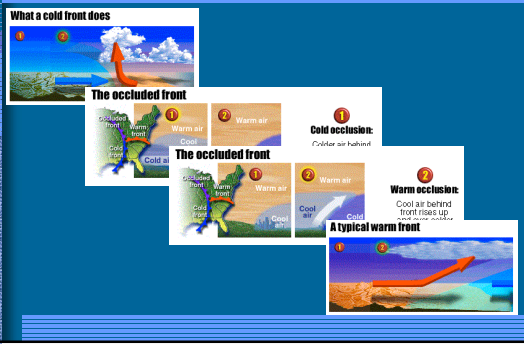
Classic Formation

Conditions for Big Storms

Tornado Climatology

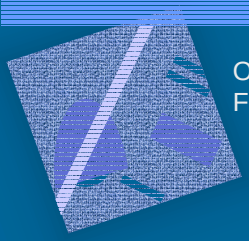


Fronts and Weather

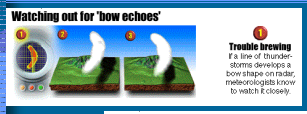


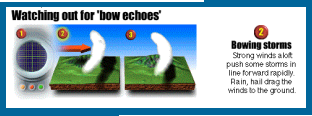
The Supercell

Other Severe Weather Features



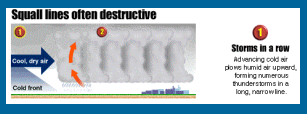
Derechos

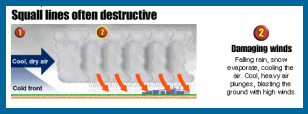




Gustfronts

Prefrontal Squalls

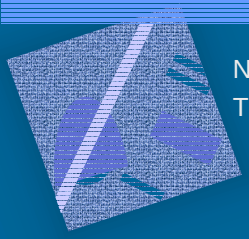




Microbursts

Microbursts & Airplanes

The Small Storms



Non-Supercell Tornadoes

Small Storms

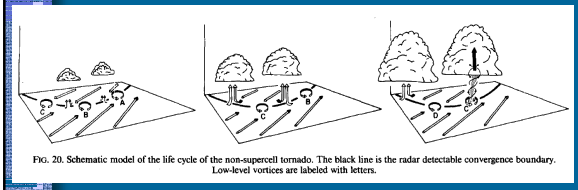
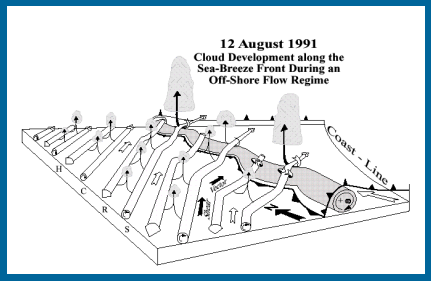


FIG. 20. Schematic model of the life cycle of the non-supercell tornado. The black line is the radar detectable convergence boundary. Low-level vortices are labeled with letters.

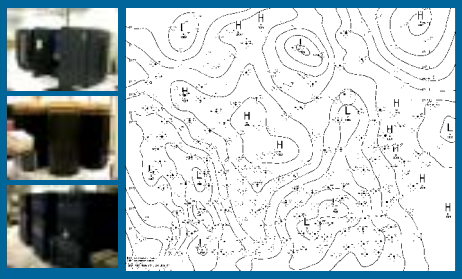


Forecasting
- current practice

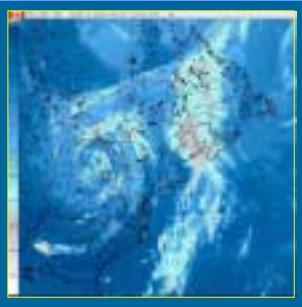
Upper Air Network

Surface Network

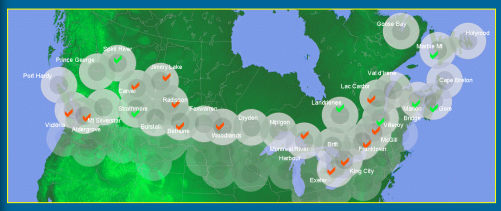
Numerical Weather Prediction



Satellite Cloud Detection

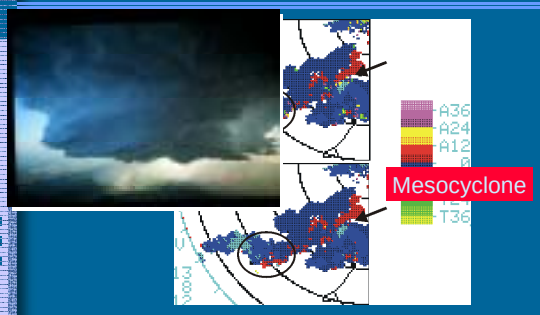


National Radar Project



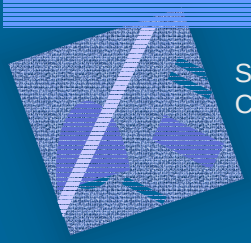
The Forecaster

Severe Weather Signature



Warning Types

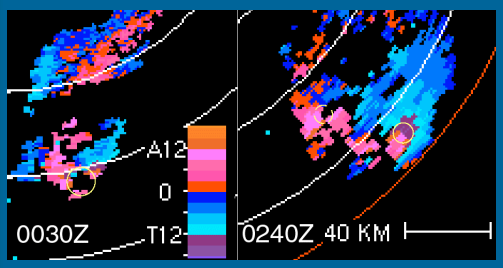
Type	*Description*
Wind	Strong winds that cause mobility problems and possible damage to vegetation and structures.
Heavy Rainfall	Heavy or prolonged rainfall accumulating on a scale sufficient to cause local/widespread flooding.
Thunderstorm	One or more of the following: strong winds causing mobility difficulty, damage to structures due to wind and hail, heavy rain that may cause local flooding and lightning.
Severe Weather	Presence of tornado(s), damaging hail, heavy rain, strong winds, life and property exposed to real threat, lightning
Tornado	Public has real potential to be exposed to tornado(s).



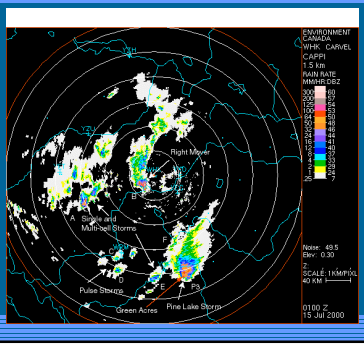
Some Recent Canadian Tornadoes

Pine Lake

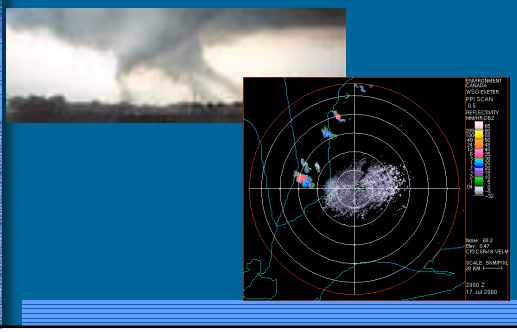
Doppler Signature



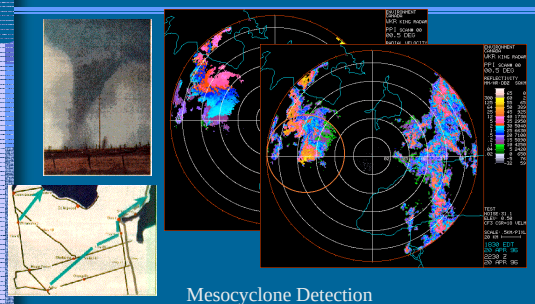
Which storm is severe?



Guelph Tornado



Williams Lake



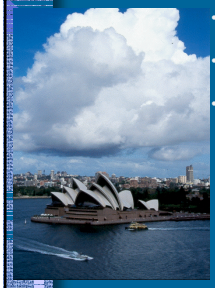
Mesocyclone Detection
Apr 20 1996 Williams Lake Tornado

What's Happening on the Ground?

The Future

Sydney 2000

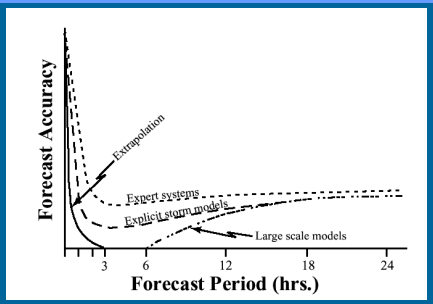
Sydney 2000



- Algorithmic Severe Weather diagnosis of the atmosphere
- Nowcasting (0+) of convective initiation and precipitation
- Combined to form the World Weather Research Program Sydney 2000 Forecast Demonstration Project

Demonstrate precision forecasting in time and space.

Forecast Ability



Nowcasting

- **Observation** based short-term forecasting
- 0 to 6/12/24 hours
- 0 hours mean knowing what is happening now
  - diagnosis (eg of severe weather)
- 0+ hours mean predicting what is happening in the future
  - prognosis
  - extrapolation

The Players

Participant	System
UK Met Office	NIMROD - 6 hour nowcasts
UK Met Office	GANDOLF - 3 hour nowcasts
Canada MSC	CARDS - 90 minutes, Severe Weather
US NCAR	Autonowcaster - 90 minutes, forecast convection
US NSSL	WDSS - Severe Weather
Australia	SPROG - 90 minutes, Polarization Radar

Clients

Real time delivery of products to BOM forecasters and external clients to use in provision of weather services

Targeted impact studies for forecast users

Nimrod 0 to 6 hrs Precip Nowcast

Successor to FRONTIERS (Forecasting Rain Optimised using New Techniques of Interactively Enhanced Radar and Satellite data) from 1997

Radar derived surface rain rate analysis

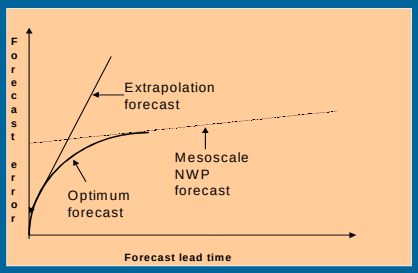
Nowcast scheme combines object-oriented rainfall advection with NWP mesoscale rainfall prediction

Inputs – synoptic observations, surface beam radar reflectivity, satellite, NWP mesoscale model outputs

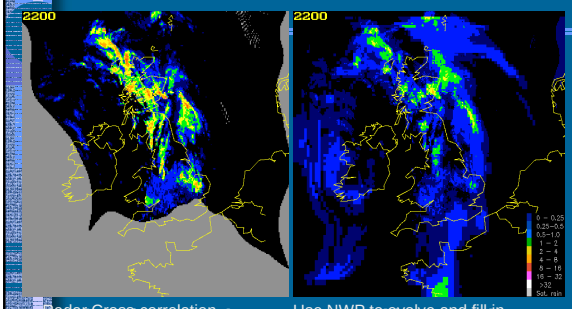
Nowcasts from 0-6 hours, 15 min. time step, 5 km resolution

Products – instantaneous rain rate, 15 minute rain accumulation, precipitation type, wind gusts

Nowcasting methodology



Nimrod extrapolation and 'merged' forecasts



Extrapolation forecast, 1-6 hours

Radar Cross-correlations

Use NWP to evolve and fill in

Merged forecast, 1-6 hours

GANDOLF 0 to 3 hours Precip Nowcast

Designed to improve nowcasts of convective rain

Radar derived 3-D rain analysis

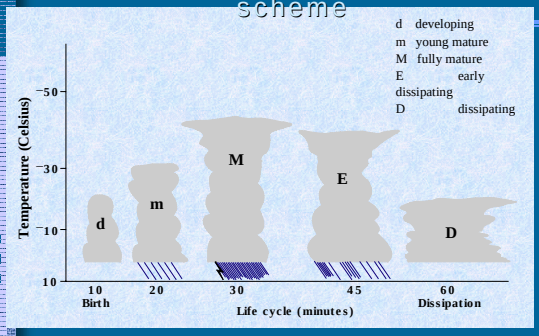
Object-oriented nowcast scheme with conceptual life cycle model of convective cell

Inputs – multi-beam / volumetric radar reflectivity, satellite, NWP mesoscale model outputs

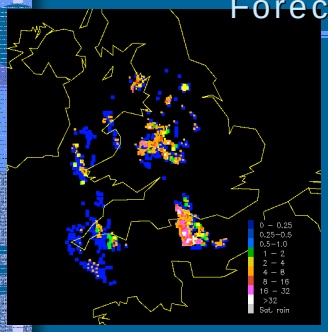
Nowcasts from 0-2 hours, 10 min. time step, 2 km resolution

Products – instantaneous rain rate, 15 minute rain accumulation, storm / cell track, (hail diagnosis, peak convective wind gust)

Life cycle of a convective cell in the Object Oriented forecast scheme



Instantaneous Rainfall Forecast

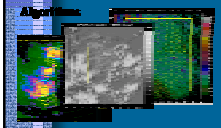


- 10 minute run cycle
- 2 km resolution
- T +10 – T+120 min. forecasts
- Cell evolution (& interaction)

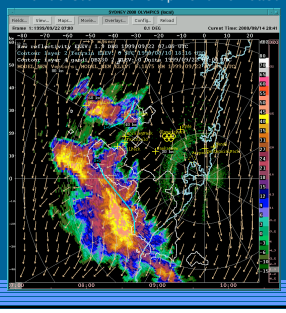
Autonowcaster Convective Initiation

Autonowcaster Using current weather observations combined with a computer-based numerical model, FUZZY LOGIC, the Autonowcaster tracks and growth is forecast for the next hour.

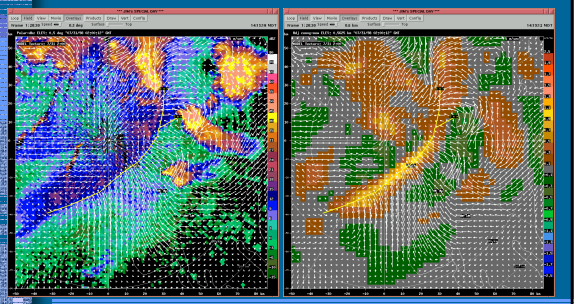
Algorithm



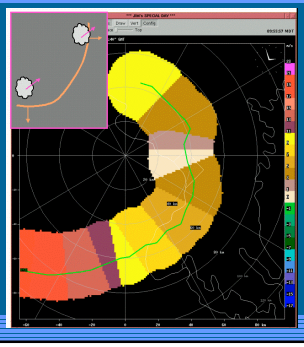
Adjoint Wind Fields
Thunderstorm Development Nowcast



Adjoint Winds and Boundary Detection Machine/Human Drawn



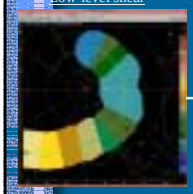
Boundary = Convective Initiation



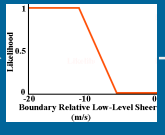
Fuzzy Logic

Example given for boundary relative low-level shear.

Low-level shear

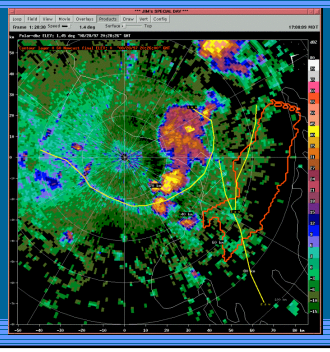


Membership function
(converts low-level shear to thunderstorm likelihood)

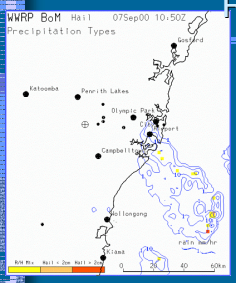


Likelihood

Final Convective Development Product



Polarimetric Radar

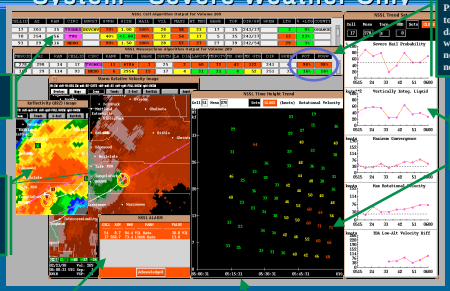


7 September 2000
Hail detection with Polarization Radar

The Bureau of Meteorology's CPOL Polarimetric Doppler Research Radar now located temporarily at Badgery's Ck in support of the Sydney 2000 Project

Example of hail collected near Horsley Park NSW

National Severe Storms Laboratory Warning Decision Support System - Severe Weather Only



Probability of tornado and damaging winds from neural network

Table ranking the most severe storms

One hour trend of storm parameters

Detects storms and vortices and forecasts their movement.

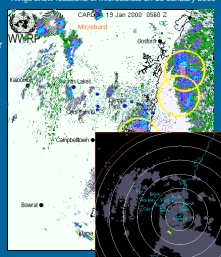
Pop-up table alerting of rapidly growing storms

Time-height trend information from 130 million data points

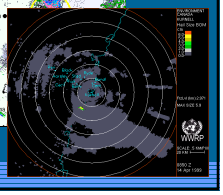
CARDS

The Canadian Atmospheric Environment has developed a system to detect the severity of individual thunderstorms. Hail, downbursts, rotating storm updrafts and other severe weather signatures are detected automatically using Doppler radar data from the Bureau of Meteorology site at Kurnell.

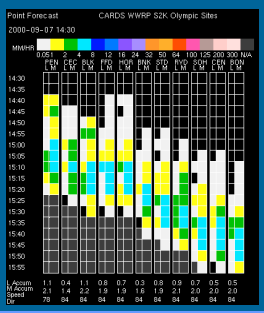
Rings show locations of microbursts on 19 January 2000



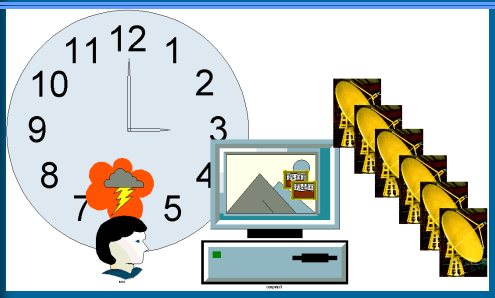
Hail



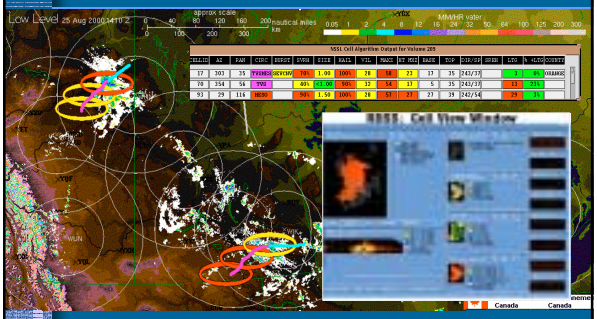
Point Forecast



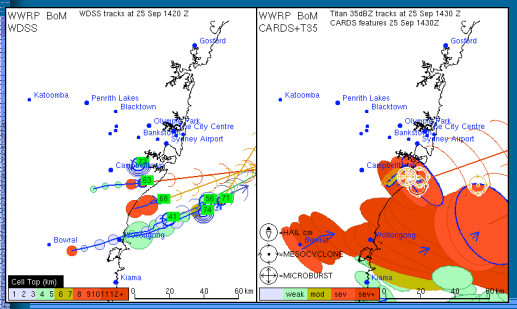
Our Reality



Cell Based Products and Access



Thunderbox/Merged Products Feature Manipulaton



Summary

- Described the variety of Tornadoes
- Described the current thinking about how they are formed
- Described how severe weather forecasting is done
- Described other tornado-like severe winds
- Described where we are going in forecasting